Environment and Ecology 40 (2) : 272—278, April—June 2022
ISSN 0970-0420

Puffing Characteristics of Different Variety of Parboiled Rice by using Domestic Microwave Oven

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Received 2 January 2022, Accepted 4 February 2022, Published on 14 May 2022

ABSTRACT

The sudden heating at high temperature short time causes expansion of the moisture present in the inter-granular spaces of the starch granules in the form of vapor which results in puffing of grains. Puffing quality varies with the variety of rice and some critical factors like, moisture content, puffing temperature, puffing methods, pre-treatments and conditioning. Present study was performed to evaluate the puffing quality of different variety of rice by microwave oven. Pre-gelatinization or parboiling is an essential unit operation given to the rice before puffing. Microwavable products are gaining worldwide acceptance as convenient foods, where hygiene can be maintained when processed in small quantities at the domestic level. Puffing characteristics were studied for three varieties of rice at different moisture content levels (10, 12, 14 and 16%, wb) and microwave power levels (600, 800 and 1000 W) at constant concentration of common salt (2%). The puffing time was kept constant as 100 s. The highest volume expansion ratio (VER) and puffing yield were found to be at 14% moisture content of the grain for all the varieties of rice at all the power levels investigated. In general, with the increase in microwave power level, the puffing yield and VER increased for all the three varieties. It was further observed that with the increase in power level, the values of puffing yield and VER increased for all the varieties irrespective of the moisture content. It was found that rice puffing gained better at high power level.

Keywords Puffing characteristics, Parboiled rice, Microwave power, Moisture content, Puffing yield.

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INTRODUCTION

It is estimated that about 10% of the total paddy production in India is used for the production of pro-

Fig. 1. Varieties of paddy (a) Barhasal, (b) Mahamaya, (c) Rajeshwari (IGKV R1).

cessed or value added rice products like popped, puffed and flaked rice (Narasimha 1995). Rice is considered to be the rich source of carbohydrates which contributes about 60 to 70% of the energy needs of the human body. This includes the contribution and availability of value added products in the form of puffed, popped, flaked, extruded products, multigrain flakes, breakfast cereals and other traditional cuisines in addition to rice as a staple food. Among the breakfast cereals made from rice, puffed rice is one which is very popular and remains on demand for centuries in India due to its typical crispness and lightness properties. It is commonly used as ready-to-eat breakfast cereal, snacks, cereal drinks and infant food. Puffed rice, a staple in the diet is not only as a major source of carbohydrate but to some extent protein and it also contributes beneficial nutrients including dietary fiber, vitamins, minerals and phytochemicals which have been linked to reduce disease risk (FDA 2006, Maisont and Narkrugsa 2009).

The snack food market is one of the most important areas of the food industry. Snack foods have always been a significant part of modern life style and they represent a distinct, constantly widening and changing group of food items. Production of snack foods today can be a complex process to meet changing consumer's expectations and their taste. Rice puffing process combines number of unit operations viz., parboiling, drying, milling and roasting. Traditionally paddy is gelatinized or parboiled by hydrothermal treatment. Lot of variations are being adopted to give hydrothermal treatment to the paddy for parboiling which may include hot water soaking, steaming and drying of moistened grains (Chandrasekhar and Chattopadhyay 1991). The aim is to achieve partial or full gelatinization, which is imper-

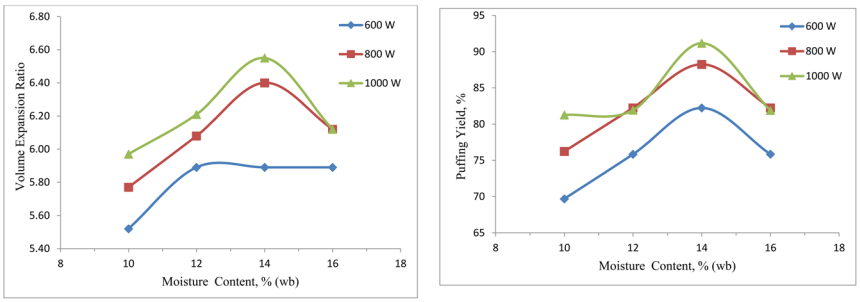

Fig. 2. Variation in volume expansion ratio and puffing yield at different microwave power level and moisture content of rice for Barhasal variety.

ative for puffing process unlike popping. Puffing is a combined process of gelatinization of starch and expansion which is accomplished by exposing the grains to a high temperature for short time. Hence, the process may be called as high temperature short time process. Normally, puffed rice is prepared from the parboiled rice by roasting in hot sand, exposing to high temperature air, hot oil puffing or gun puffing methods. Recently the possibility of microwave puffing has also been explored for puffing of cereals. With the advancement of time, puffing of rice on hot sand bed has been replaced to some extent by gun puffing method. However, the infrastructure and operational cost of gun puffing system is quite high compared to hot sand puffing technique. Microwave energy could be well applied for baking, roasting, puffing and popping. The successful use of microwave oven for popping the corn had made headway for the puffing or popping of cereals. Some of the benefits from the microwave heating (popping process) such as quick start-up time, faster heating in reaching popping temperature, energy efficient, low space requirements, selective heating over traditional process cannot be ignored. Additionally, there is no need for pressure vessel and personal skill (Maisont and Narkrugsa 2009, Kumar *et al.* 2017).

In the process of puffing or popping the cereals using microwave energy, the microwave heats the grain through vibrational energy transferred to grain moisture. Due to this, necessary superheated steam is regenerated out of the moisture contained therein during heating and accumulated at the center of the grain thereby creating a local high pressure at the nuclei leading to expansion of the grain. Use of microwave heating is considered to be inexpensive process which offers unique advantages such as quick heating and convenience for expansion of foods. Microwave heating is one of the most popular especially in United States for expansion of popcorn (Moraru and Kokini 2003).

Puffed rice is usually appreciated and popular due to its crispy texture, lightness and qualities related to its cellular structure. The conversion of compact rice into an expanded structure, the grain has

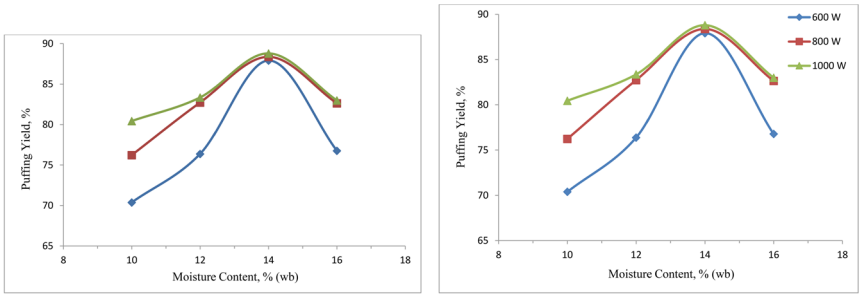

Fig. 3. Variation in volume expansion ratio and puffing yield at different microwave power level and moisture content of rice for Mahamaya variety.

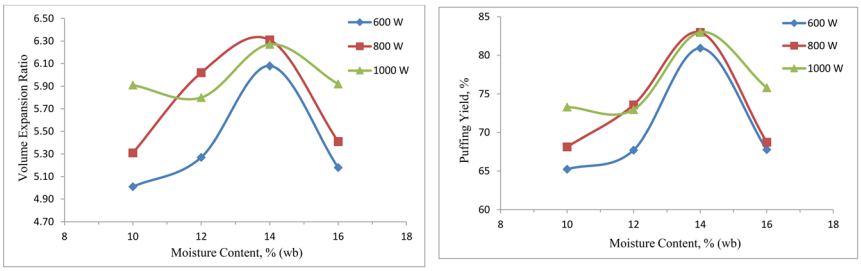

Fig. 4. Variation in volume expansion ratio and puffing yield at different microwave power level and moisture content of rice for Rajeshwari variety.

to pass through series of stages or the unit operations during the puffing process. Considering the above facts, present study was undertaken to characterize the puffing characteristics of three varieties of parboiled milled rice through a domestic microwave oven.

MATERIALS AND METHODS

Three varieties of paddy namely; Mahamaya, Rajeshwari (IGKV R1) and Barhasal were procured from the storage center of the Department of Plant Breeding and Genetics and National Seed Project, IGKV, Raipur (CG). From all the paddy varieties specks of dirt and foreign materials were properly removed. Parboiling was performed as a pretreatment for production of puffed rice, for which paddy samples were soaked in Luke warm water (50°C) for overnight followed by steaming for 25–30 min (Hoke *et al.* 2005).

The puffing experiments on microwave were accomplished using a domestic microwave oven (LG, MB-394AA, 2450 MHz, made in Korea) to investigate the puffing characteristics of three selected varieties of rice. These three varieties of paddy samples are presented in Fig.1. This has the facility of regulating the power level in the range of 100 to 1200 W. The entire experiment was conducted in the microwave mode. In this method, power level of microwave was varied in the range of 600 to 1000 W, whereas the levels of moisture content of rice samples was kept 10 to 16% (wb). In order to puff the rice, known weight of pre-prepared (treated with 2% concentration of salt) rice kernel samples were placed on the glass disc provided with the microwave. The puffing time was kept constant as 100 s. To study the effect of variety on puffing characteristics acomparative performance of the three test varieties on VER and puffing yield was studied at the microwave power of 800 W with the variation in moisture contents from 10 to 16% (wb).

Volume expansion ratio

The volume expansion ratio is the ratio of the volume of the puffed sample to the volume of the rice sample before puffing (pre-gelatinized rice).

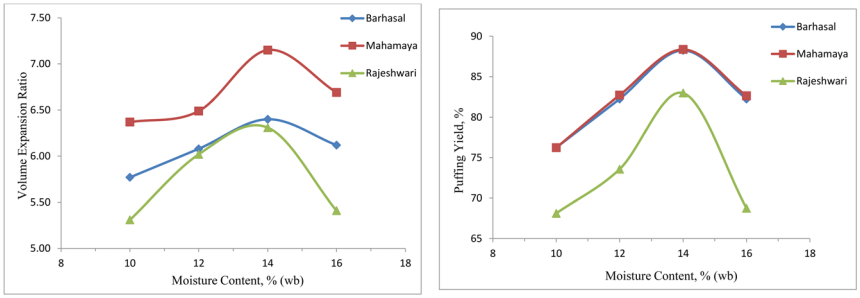

Fig. 5. Comparison of volume expansion ratio and puffing yield for three test varieties of rice at 800W microwave power level.

Fig. 6. Puffed rice prepared from test varieties of rice.

The volume expansion ratio was measured by sand replacement method (Chinnaswami and Bhattacharya 1983, Joshi *et al.* 2014) using the following equation (Eq. 1).

$$\text{Volume expansion ratio} = \frac{\text{Volume of puffed rice (ml)}}{\text{Volume of sample before puffing (ml)}} \quad (1)$$

Puffing yield

Puffing yield is the ratio of the weight of puffed rice to the total weight of the raw rice sample (Maisont and Narkrugsa 2009). Puffed and un-puffed rice were separated manually from the collected sample and weighted. The puffing yield of the sample was calculated using the following relationship (Eq. 2).

$$\text{Puffing yield (\%)} = \frac{\text{Weight of puffed rice (g)}}{\text{Total weight of the sample (g)}} \times 100 \quad (2)$$

Statistical analysis

Statistical analysis of variance (ANOVA) was performed through Microsoft excel. In order to execute the experiments systematically full factorial design was adopted to find out the effect of the process parameters (independent) on responses or the dependent variables.

RESULTS AND DISCUSSION

The maximum and minimum puffing yield for Mahamaya, Barhasal and Rajeshwari rice were recorded to be 88.79% and 70.38%, 91.16% and 69.68% and 82.99% and 65.23%, respectively. Similarly, the maximum and minimum VER for these varieties were found to be 7.09 and 5.99, 6.55 and 5.52 and 6.27 and 5.01. It can be seen from the figures (Figs. 2–4) that the highest value of both the indicators VER and puffing yield were found to be at 14% moisture content of the grains for all the varieties of parboiled rice. This behavior is true for all the varieties of rice and at all the power levels investigated. In general, with the increase in microwave power level, the puffing yield and VER increased for all the three varieties.

It was further observed that with the increase in power level, the values of puffing yield and VER increased for all the varieties irrespective of the moisture content. The puffing yield and VER increased initially as the moisture content increased from 10 to 14% level and then decreased with increase in moisture content to 16%. Similar findings have been reported by Solanki *et al.* (2018) in case of maize popping. Hoseney *et al.* (1983) explained that excessive moisture content adversely affects and results in a higher un-puffed kernel ratio. Maisont and Narkrugsa (2010) have also indicated the reduction in puffing yield at higher moisture content. Further, at lower power level, the puffing yield and VER both had the minimum values. The probable reason could be that at lower power level the samples do not get continuous supply of energy at the desired magnitude essentially required for the puffing. Similar findings have been reported by Joshi *et al.* (2014) in case of rice puffing.

It can be seen from the Fig. 5 that the puffing behavior of all three varieties are identical. However, the puffing characteristics of all the three varieties were found to be varied with the variation in kernel moisture content at constant microwave power (800 W). The Mahamaya variety of rice was found to be best in respect of both the quality of volume expansion ratio and puffing yield by domastic microwave oven puffing method. Fig. 6 shows the color and quality of puffed rice produced from experimental raw rice varieties and Mahamaya variety was found to be best for puffing. Similar result has also been reported by Mishra *et al*. (2014) in case of sorghum popping.

CONCLUSION

The highest values of puffing yield and VER were recorded at 14% (wb) moisture content and 1000 W microwave power level of the rice for all the three varieties. The puffing yield and VER were observed to be increased initially as the moisture content increased from 10 to 14% (wb) beyond which both decreased sharply. From the experimentation, it can be concluded that the puffing characteristics of parboiled rice of test varieties (Mahamaya, Barhasal and Rajeshwari) was found to be affected by the moisture content of the rice and microwave power level in addition to the variety of rice. From all the three experimental variety of rice, Mahamaya rice was found to be most suited for the development of puffed rice with high volume expansion ratio and puffing yield through domestic microwave oven puffing.

ACKNOWLEDGEMENT

The authors are grateful to the Department of Agricultural Processing and Food Engineering, Faculty of Agricultural Engineering, Department of Plant Breeding, Genetics and National Seed Project, IGKV, Raipur (CG) for valuable guidance, constant inspiration and moral support throughout the research work.

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